SOUTHERN CONVEYOR PROJECT PHASE II
CYPRUS

FINAL ENGINEERING CONSULTANCY SERVICES REPORT

By: Z. Smiljkovic

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Energoprojekt – Hidroinzenjering
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FINAL ENGINEERING CONSULTANCY SERVICES REPORT
for
SOUTHERN CONVEYOR PROJECT, PHASE II,
CYPRUS

Editor
Energoprojekt – Hidroinzenjering, Beograd, Yugoslavia
P. VUCKOVIC, M. Sc., Director

Quality Assurance control
I. TUCOVIC,
President of Energoprojekt – Hidroinzenjering's Board of Experts

Principal Author
Z. SMILJKOVIC,
Consultancy Project Manager of SCP II

With contributions from
Pumping Plants Engineering
P. VUCKOVIC, M. Sc,
Under his capacity as the Director of EP - Hidroinzenjering

Underground Structures Engineering
S. PERISIC,
Under his capacity as the Deputy Director of EP-Hidroinzenjering

Water Conveyance Engineering
I. NENKOV,
Engineer’s Representative for Tersephanou – Nicosia Conveyance System, the component of SCP II, 1996 to 2000.

Water Treatment Engineering
A. TUCOVIC, M. Sc.
Under his capacity as the Assistant Director of EP-Hidroinzenjering

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CHR. CRIDIOTIS, the Head of Construction Division of WDD, Nicosia, Cyprus,
SN. ALETRAS, the Project Manager of Tersephanou Water Treatment Plant, the component of SCP II,
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C O N T E N T S

Definitions and Abbreviations iii
Preface iv

1. BRIEF DESCRIPTION OF PROJECT 1

2. BRIEF DESCRIPTION OF THE COMPONENTS INCLUDED IN THE SECOND PHASE OF THE PROJECT 2
   2.1. Dhiarizos Diversion System 2
   2.2. Irrigation Distribution Systems 4
   2.3. Water Treatment Plants – Limassol WTP and Tersephanou WTP 6
   2.4. Tersephanou Pumping Station and Tersephanou – Nicosia Conveyance System 9

3. PROJECT IMPLEMENTATION DATA (Phase II) 11
   3.1. Fundamentals of Project Implementation Method 11
   3.2. Gross Implementation Stages of Project (Phase II) 12
   3.3. As recorded Implementation Schedule of Project (Phase II) 12
   3.4. The Employer and the Consulting Engineers 13
   3.5. Contracts Strategy 14
   3.6. Present Construction Cost of the Project 15
   3.7. Indicative Implementation Indexes of the Project (Phase II) 17
   3.8. Project Financing (Phase II) 18
   3.9. Consulting Engineer’s Project Management Structure (Phase II) 19

4. REFERENCED DOCUMENTATION 20
DEFINITIONS

THE EMPLOYER
The Water Development Department of Ministry of Agriculture Natural Resources and Environment, of Government of Republic of Cyprus.
Ph. ..357-2-803 100, Fax ..357-2-675 019, E-mail: roc2@cy tanet.com.cy

THE CONSULTING ENGINEER and THE ENGINEER
The Energoprojekt – Hidroinzenjering, Beograd, Yugoslavia.
Ph. ..381 11 311 4491, Fax ..381 11 311 1979, E mail: ehidro@Eunet.yu

THE PROJECT
The Southern Conveyor Project phase II - Cyprus

THE CONTRACTOR(s)
The Contractor(s) to whom the scheduled portions of works were awarded for execution

THE W.T. PLANT(s)
The water treatment plants included in Southern Conveyor Project, phase II - Cyprus

ABBREVIATIONS

SCP II Southern Conveyor Project, phase two, Cyprus
WDD Water Development Department of Ministry of Agriculture Natural Resources and Environment, of the Republic of Cyprus
TWTP Tersephanou Water Treatment Plant, the component of Southern Conveyor Project phase two, in Cyprus
TPS Tersephanou Pumping Station, the component of Southern Conveyor Project, phase two, in Cyprus
LWTP Limassol Water Treatment Plant, the component of Southern Conveyor Project, phase two, in Cyprus
DI Ductile iron (pipes)
RE/ARE Resident Engineer/Assistant Resident Engineer
Ever since its very early stage, the Southern Conveyor Project, Phase II, embraced a commitment to working collaboratively of all the Parties involved in its implementation. In its 15 years design and construction history (1986 to 2000), apart from the Employer and the Consulting Engineer, the Project involved an appreciable number of qualified Contractors. Construction of the Project embraced 8 local and overseas Contractors, many more Subcontractors and equipment Suppliers from all over the Europe. In achieving the design goals and smooth operation of the Project, the planning, consulting and construction engineers involved had proved themselves being the global leaders for building a better quality life.

Hence, although located in the small Island of Cyprus, the Project attracted international involvement during its implementation ever since its commencement (1986). The Project had a challenging expanse across a 120 km long area beginning from Arminou Village of Paphos region in the West, to Nicosia City the capital of the Island. The present worth of the Project has been evaluated to be US$ 109 M.

Serviceability wise, the Project is scheduled to satisfy water demands of southern coastal and inland regions of the Island until year 2030. In achieving this goal, an appreciable number of the Consultant’s and the Employer’s engineers had been working hard on providing solutions covering several engineering fields such as – water conveyance, land irrigation and water treatment for domestic water supply.

The Consulting Engineers thank the Employer and the Contractors of Southern Conveyor Project Phase II, for an enviable cooperation maintained all along from 1986 onwards to the benefit of the Project.

The Principal Author
On behalf of the Consulting Engineer
1. BRIEF DESCRIPTION OF PROJECT
First and second phase

Before 1974, the water development in Cyprus was primarily orientated towards the utilization of underground resources. The increase of population, growing touristic infrastructure and expansion of some industrial plants, had in the early eighties raised the water demand and created an acute shortage of water in the Island. Under these circumstances, implementation of the Southern Conveyor Project (referred to hereinafter as the SCP) was a necessity and basic prerequisite for further agricultural and economic development of the southern region of Cyprus Island, especially following the depletion of the Kokkinochoria aquifer due to over pumping.

The basic objective of the Project was to collect and store surplus water flowing to the sea and to convey it to the areas of demand for both domestic water supply and irrigation. Basically, the Project focused the agricultural development of the southern coast region of the Island extending between the cities of Limassol and Famagusta, as well as the domestic water demand of the cities of Limassol, Larnaca and Nicosia. The Project area stretches across the southern coast between the Dhiarizos River in the West and Kokkonokoria area in the East.

The Southern Conveyor Project is the largest water development project ever undertaken by the Government of Cyprus. In view of the large investment and lengthy construction period involved, the implementation of the Project was executed in two phases.

Phase one of the Project started in 1984. It included construction of Kouris Dam on Kouris river with a capacity of 115 MCM, the 110 km long main conveyor, the Akhna Terminal Reservoir with capacity of 6.8 MCM, the Kokkinokhoria, Athienou, Troulli and Avdellero Irrigation Systems having total area of a 9 767 hectares. Phase I of the Project was completed in 1994.
Phase II of the Project (referred to hereinafter as the SCP II), included the Dhiarizos Diversion System conveying water from Dhiarizos River to Kouris Reservoir, the Limassol and Tersephanou Water Treatment Plants, the Akrotiri, Mazotos, Parekklisha and Kiti Irrigation Distribution Systems, the Tersephanou Pumping Station and Tersephanou – Nicosia Conveyance System. Phase II of the Project was completed in 1999.

The succeeding paragraphs of the Report provide more details about the second phase of the Project.

2. BRIEF DESCRIPTION OF THE COMPONENTS INCLUDED IN THE SECOND PHASE OF THE PROJECT

2.1. Dhiarizos Diversion System

The System is composed of:
- Ductile Iron (DI) pipeline 1 600 mm in dia and 1 600 m in length, equipped with on line equipment for flow regulation and measurement, and for maintenance of pipeline.
- The 14.48 km long diversion tunnel with in situ cast concrete lining. The running (inner) and the peripheral (outer) diameters of the tunnel section were 2.50 and 3.00 m respectively.
- Khapotami off-take scheme, consisting in general of – a gravity weir with tirollien type off – take and settling chamber, the 220 m deep drop shaft, and the pressure sustaining/reducing valves at its bottom intended for flow regulation.

Schematic Presentation of Dhiarizos System along the water stream
Basically, the aim of the system was to divert flow rates of up to 6.0 m$^3$/s from Dhiarizos River and to convey them to Kryos River, recharging thus in the Kouris Reservoir. Another 0.5 m$^3$/s flow rate is provided from Khapotami River and transferred to the tunnel through a 220m deep shaft. Thus, the designed discharge of the System comes to 6.5 m$^3$/s. The pressure flow regimes are present along the DI pipeline, the inlet section of the tunnel and through the drop shaft. The free flow regime is maintained along the greatest length of the diversion tunnel.

Because of considerable flow variations in Dhiarizos and Kapothami Rivers, the annual volume of water to be diverted there from to Kouris dam Reservoir, was scheduled to be 23.5 MCM. This quantity of water corresponds to mean annual flow through the System of approximately 0.75 m$^3$/s. Hence, inclusion of the Dhiarizos System in the Project has defacto augmented the natural catchment's area of the Kouris Reservoir i.e. the annual yield of the Reservoir.

The diversion tunnel route traverses the lithology of Paleocene and Miocene age structured chalks, chalky marls, marls, mudstones and calcarenites, which are interbedded with each other. A limited quantity of ground water inflow along the tunnel route was encountered. A relatively consistent lithology dictated in advance the use of tunnel boring machine for tunnel construction. The tunnel boring was followed up by occasional application of shotcrete protective lining and steel arches. Very limited sections of the Tunnel were constructed with reinforced concrete lining. The unreinforced concrete tunnel lining was constructed along the major part of the tunnel. The concrete lining of the tunnel was cast in situ after the tunnel had been entirely driven.

A sophisticated approach using the finite elements method was used to evaluate the stress-strain conditions in the lining and the surrounding rock mass.

The System was put in operation in 1996.
2.2. Irrigation Distribution Systems

Within the framework of Southern Conveyor Project, phase II, four areas were designed to receive water for irrigation. The conveyance of this water is ensured through the southern conveyor pipeline. The four Irrigation Systems are named – Akrotiri, Parekklishia, Mazotos and Kiti. The 3 909 Ha gross irrigation area of the Irrigation Systems, stretches across the southern coastal region of Cyprus Island. Because of circumstances related to land consolidation, the Mazotos Irrigation Distribution System was eventually abandoned and left for further planning of the Project in the future.

Each Irrigation System is connected to the main conveyor pipeline through conveyor branches. The distribution network of the System consists of pipelines with a configuration that fits crop patterns and topography. The pipes forming the network are:
- Ductile iron (DI) for Conveyor branches towards the Night Storage reservoirs for a particular area,
- Asbestos cement (AC), for the main distribution network, and
- Plastic (PVC), for farm lines, extending between the hydrants and the farm outlets.
Cropping pattern, including – citrus, potatoes, onions, grapes, tomatoes, table olives, artichokes, ground nuts, summer and winter vegetables, - were considered in determining the capacities of night storage reservoirs and the distribution networks.

The distribution network is of ‘open type’ consisting of pressurized pipelines. The majority of the networks is pressurized by gravity and fed from the night storage reservoirs, which are sited at higher elevations.

The crop water requirements were assessed using a computer program, which took into account the parameters such as crop evapotranspiration, consumptive use at maximum yield, effective rainfall, soil water deficits and relationship between consumptive use and yield. The chemical analyses of water from the conveyor indicated that the concentration of salts, alkali, boron and potentially toxic metals were all well below levels, which could cause damage to either crops or soil.
Because of distinct advantages associated with the ‘on demand’ system as compared to the ‘on rotation’ system, the former was adopted for the four irrigation areas of 2nd phase of the Project.

The on-farm systems, which were adopted as appropriate for the irrigation areas, are:
- Sprinkler method, and
- Trickle (dripping) method.

The selection of suitable on – farm system for a particular crop was based on agronomic, climatic and economic factors. Thus, the sprinkler irrigation method is intended to serve potatoes, onions and fodder only.

Because it is a highly efficient and labour saving method, and due to a favourable response by most of the crops, the trickle irrigation method was envisaged for all other crops and plantations. In these cases however, because of potential clogging of emitters by water carried substances such as – algae, sand and undissolved fertilizers, the distribution network is equipped by appropriate filter at the head of farm lines.

The 2nd phase of Irrigation Distribution Systems have been gradually put into operation during the period 1994 to 1999.

2.3. Water Treatment Plants: Limassol WTP and Tersephanou WTP

Basically, the Plants are being fed by upland water stored in Kouris Reservoir and conveyed via the southern conveyor pipeline up to the Plant's intakes. The process lines of the Plants are accommodated such as to comply with Categories A1 and A2 of water treatment stipulated in EU Directives for water quality specified for human consumption.

The capacities of the Plants are:
- Limassol WTP – 40 000 m³/day, with the provision to extension to 80 000 m³/day,
- Tersephanou WTP – 60 000 m³/day, with the provision to extension to 90 000 m³/day.
The Limassol WTP is located 2km North of Limassol city. The Plant will augment the water supply of Limassol city, the municipalities adjoining the city and the British Military Base of Akrotiri.

The Tersephanou WTP is located approximately 9 km West of Larnaca city. The Plant is intended to improve water supply of the cities of Nicosia and Larnaca and the Government controlled area of Famagusta.

Process lines of the Plants encompass intensive physical and chemical treatment of raw water, including in general:

- Pre-chlorination,
- Coagulation, flocculation and sedimentation,
- Rapid sand filtration,
- PH correction, and
- Desinfection (post-chlorination).
The polyelectrolyte and aluminum sulfate are used as coagulant aids during water clarification. In addition, a provision was made for future applications to both the Plants, of ozone and granular activated carbon with the aim of pesticides and herbicides removal from raw water.

The structures of the process blocks of the Plants are accommodated in such a way as to ensure free hydraulic regime along the stages of water treatment. Ductile iron pipes and fittings serve as indoor and outdoor water conduits. Flow measurement and control is achieved by flow meters, control valves, penstocks and isolating valves.

Electric power supply of the Plants is provided through their own transformer stations 11/0415 kVA. The power is distributed from the main switchboard via sub-distribution boards at appropriate locations. In case of power failure, the emergency power supply is secured from the plants’ diesel generators.

Semi-automatic operation of the Plants is provided. Once the chemicals are manually prepared and the doses set, the Plants can operate fully automatic, including the filtration control, de-activation of filters for backwashing, backwashing sequences and activation of filters back to filtration. Besides, all relevant hydraulic and process parameters are continuously monitored and recorded.

Block system of reinforced concrete structures cast in situ was adopted to serve for the water treatment, water retaining and water storing, chemicals preparation and storing, service pumping station and, for control and administrative premises of the Plants. The structures are founded on sub-horizontally stratified and inter-bedded chalky- marl bedrock formation. The structures are envisaged to withstand seismic loads induced by 0.25g of ground horizontal acceleration.

The Limassol and Tersephanou WTPs were put into operation in 1994 and 1999 respectively.
2.4. Tersephanou Pumping Station and Tersephanou-Nicosia Conveyance System

The Pumping Station and the Conveyance System are both intended to transport the additional potable water quantities to Nicosia consumer areas. The Pumping Station is located adjacent to the treated water reservoir of Tersephanou Water Treatment Plant. The Tersephanou-Nicosia Conveyance System is 37 km long and extends from Tersephanou WTP to Lakatamia water distribution reservoir just outside the city of Nicosia.

Out of 37 km of the Tersephanou-Nicosia Conveyance System, 19 km relates to the pumping main while 18 km to the gravity main. The balancing of flows between the pumping and gravity main is achieved by a 12 000 m³ balancing reservoir which is set at the highest elevation of the System route.
The total hydraulic head between the water levels in the balancing reservoir and the suction chamber of the Pumping Station, including static head and on-line hydraulic losses for steady flow conditions, reaches 19.5 bars, which was meritorious for the design of the pumping system.

The Pumping Station is equipped with five horizontal centrifugal pumps driven by fixed squirrel cage electric motors. Four of them are envisaged to operate in parallel, while the 5th one is ‘stand by’. The capacity of a single pump at 19.5 bar static head is 225 l/s. The basic characteristics of pump motors are: 750 kW input power, 415/240 V voltage and 50 Hz frequency.

Total discharge capacity of the Pumping Station for normal operation regime and with four pumps in parallel operation is 900 l/s or, 77 750 m³/daily of water delivered to Dhali balancing reservoir. The total power consumption of the Pumping Station whilst four pumps are in operation aggregates to 3 MW. In case of power failure, emergency power supply for one delivery pump is automatically secured from a 1 750 KVA diesel generator unit. Depending on the levels in the suction and delivery tanks, the Pumping Station is provided for full automatic operation.

The Pumping Station was put in operation in 1998.

The Pumping Station and the pumping main of the Conveyance System are protected against excessive hydraulic surges by two pressure vessels of 17.5-m³ effective volumes each. A sophisticated program for modeling transient phenomena in the pumping main was used to evaluate optimum anti-surge protection of the pumping system.
The pumping and gravity mains of the Conveyance System consist of – DN 900 ductile iron pipes equipped with single and double orifice air valves, flow meter at the beginning of pumping main and a number of isolating valves. Besides, control of flow through gravity main is achieved via appropriate control valves installed in inlet and outlet sections of the main. Both pumping and gravity main are provided with swabbing inlet and outlet installations intended for periodical swabbing of incrustations precipitated on the pipe’s walls. Capacity of gravity main corresponds to the Pumping Station capacity i.e. to 900 l/s or, 77,750 m³/day of drinking water.

Water tightness of both pumping and gravity main of the Conveyance System was checked at a hydraulic pressure of 26 bar.

Commercial use of the Tersephanou-Nicosia Conveyance System coincided with the commencement of operation of the Pumping Station, i.e. May 1998.

3. PROJECT IMPLEMENTATION DATA (Phase II)

3.1. Fundamentals of Project Implementation Method
3.2. Gross Implementation Stages of Project (Phase II)

STAGE I - FEASIBILITY STUDIES
Based at large on appropriate investigation of:
- Water resources and water demands,
- Water quality,
- Infrastructural, environmental, topographical and geological conditions

STAGE II - DESIGNS AND TENDER DOCUMENTS
- Additional water quality, topographical and geological investigations,
- Setting out contracts strategy,
- Design criteria and detailed designs,
- Cost appraisals,
- Preparation of tender documents,
- Invitation for tenders submission,
- Evaluation of competitive contractors & suppliers bids.

STAGE III - CONSTRUCTION & SUPERVISION
- Civil engineering works
- Supply and installation of equipment
- Tests on completion and Trial Run

3.3. As recorded Implementation Schedule of Project (Phase II)

STAGE I - Feasibility Studies: 1980 to 1982
STAGE II – Designs, tender documents and contracts award: 1986 to 1992
STAGE III – Construction and supervision: 1990 to 1999
3.4. The Employer and the Consulting Engineers (Phase II)

**The Employer**

**WATER DEVELOPMENT DEPARTMENT**
of Ministry of Agriculture, Natural Resources and Environment of Government of Republic of Cyprus.
Tel: ..3572 803-100, Fax: ..3572 675-019
E-Mail: roc2@cytanet.com.cy

**The Consulting Engineers**

**SIR WILLIAM HALCROW & PARTNERS**
Balfours, UK,

Jointly with

**The Employer i.e. the Water Development Department,**
Nicosia, Cyprus

Additional investigation programs, Detailed Designs and preparation of Tender documents (1986 –1992)
**ENERGPOROJEKT-HIDROINZENJERING**
11 070 Beograd, Yugoslavia, 12 Mihaila Pupina Str.
Tel. ..381 11 311-4491, Fax: ..381 11 311-1979
E-Mail: ehidro@EUnet.yu

**The Engineer**

**Coordination of Contractors, Contracts administration and Works supervision (1990 – 2000)**
**ENERGPOROJEKT-HIDROINZENJERING**
Beograd, Yugoslavia,

Jointly with

**The Employer i.e. the Water Development Department,**
Nicosia, Cyprus
### 3.5. Contracts Strategy

Contracts Strategy of Southern Conveyor Project phase II was outlined such as to suit the scope and nature of works involved.

<table>
<thead>
<tr>
<th>CONTRACT BASIS CONSIDERED</th>
<th>CONTRACT OPTION APPLIED</th>
</tr>
</thead>
</table>
| **A** Method of works measurement and payment | 1. Re-measurable Contracts  
2. Turn-key Contracts |
| **B** General and Special Conditions of Contract | 3. Conditions of Contract for work of civil engineering construction, Fourth Edition 1987, by Federation Internationale des Engineers-Conseils, duly amended by the Consulting Engineer to suit local conditions and the needs of the Employer. Effective to re-measurable Contract options for civil engineering works where scheduled in the Project.  
4. Conditions of Contract for electrical and mechanical works, including erection on site, Third Edition 1987, by Federation Internationale des Engineers-Conseils, duly amended by the Consulting Engineer to suit local conditions and the needs of the Employer. Effective to re-measurable Contract options for supply and installation of electromechanical equipment where scheduled in the Project.  
6. A combination of Conditions for civil engineering construction and for electrical and mechanical works accommodated by the Consulting Engineer to suit the nature of turnkey contracting. Effective to Turnkey Contract options where scheduled in the Project. |
| **C** Method of Project Implementation and Management | 7. Single Contract option for a Project Component completion  
8. Multi-Contracts option for a Project Component completion |

**Notes:** Construction of Irrigation Distribution Systems was carried out and supervised by the Employer.
3.6. Present Construction Cost of the Project (Phase II)

Present construction cost of the Project Components was appraised by revision as at the end of year 2000 of their original price(s) or, of totally certified amounts of the Contract(s) involved, bearing in mind 5% average annual escalation rate. To this effect, the exchange rate of 1.60 US Dollar for 1.00 CY Pound, was used. A comparable cost schedule of the separate Project Components was the aim of the analyses.

<table>
<thead>
<tr>
<th>PROJECT COMPONENT</th>
<th>CONTRACT OPTION APPLIED</th>
<th>COST AT THE END OF 2000 IN MILLIONS OF US DOLLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 DHIARIZOS DIVERSION SYSTEM</strong></td>
<td>Re-measurable – Single Contract Option. C1 CONTRACT</td>
<td>32,5 M</td>
</tr>
<tr>
<td><strong>2 IRRIGATION DISTRIBUTION SYSTEMS</strong></td>
<td>Constructed and supervised by the Employer</td>
<td>19,7 M</td>
</tr>
<tr>
<td><strong>3 LIMASSOL WATER TREATMENT PLANT</strong></td>
<td>Turn – key - Single Contract basis. T1 CONTRACT</td>
<td>19,7 M</td>
</tr>
<tr>
<td>*) The construction cost of the Plant was increased by 25% by virtue of implementation of additional process lines such to augment the Plant capacity from 40 000 m³/day to 80 000 m³/day.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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/……….Continued from previous page
<table>
<thead>
<tr>
<th>PROJECT COMPONENT</th>
<th>CONTRACT OPTION APPLIED</th>
<th>COST AT THE END OF 2000 IN MILLIONS OF US DOLLAR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4</strong> TERSEPHANOU WATER TREATMENT PLANT</td>
<td></td>
<td><strong>21,1 M</strong></td>
</tr>
<tr>
<td>Process Line: Pre-chlorination, coagulation, flocculation, filtration, PH correction and disinfection (post-chlorination).</td>
<td>Re-measurable – Multi Contracts Option. C3 CONTRACT (C/E works) S6 CONTRACT (E/M works)</td>
<td></td>
</tr>
<tr>
<td>Final capacity of the Plant: 90 000 m³/day.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Present cost appraisal in £:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C3 Contract – Civil engineering works:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>£ 3.15 M(1995) x 1.055(2000) + 0.5 M(SI/VOs) = £ 4.5 M(2000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S6 Contract – Supply and installation of equipment:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sub-total</td>
<td>£ 10.6 M(2000)</td>
<td></td>
</tr>
<tr>
<td>+ 25%*) for additional process lines</td>
<td>£ 2.6 M(2000)</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>£ 13.2 M(2000)</td>
<td></td>
</tr>
<tr>
<td>*): The construction cost of the Plant was increased by 25% by virtue of implementation of additional process lines such to augment the Plant capacity from 60 000 m³/day to 90 000 m³/day.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| **5** TERSEPHANOU PUMPING STATION (Electromechanical Works) | | **1,9 M** |
| Capacity of Pumping Station in normal operation regime: 77 750 m³/day. Total input power of pump motors: 3 MW. Emergency power supply is secured for one pump. | Re-measurable Contract. S3 CONTRACT (E/M works). In view of its management and implementation, the Contract was included in Tersephanou WTP contracts package. | |
| Present cost appraisal in £: | | |
| C3 Contract – Civil engineering works: | | |
| £ 0.82 M(1995) x 1.055(2000) + 0.14 M(SI/VOs) = £ 1.2 M(2000) | | |

| **6** TERSEPHANOU-NICOSIA CONVEYANCE SYSTEM | | **14,1 M** |
| The system is consisted of: 37 km long DI pipeline including on line equipment and 12 000 m³ balancing reservoir. Capacity of the System: 77 750 m³/day. | Re-measurable – Multi Contracts Option. C2 CONTRACT (C/E works) S1 CONTRACT (Supply of pipes) S1 CONTRACT (Supply of equipment) | |
| Present cost appraisal in £: | | |
| C2 Contract-Civil works, including erection of equipment: | | |
| £ 2.1 M(1996) x 1.054(2000) + 0.6 M(SI/VOs) = £ 3.1 M(2000) | | |
| S1 Contract-Supply of ductile iron pipes: | | |
| S2 Contract-Supply of valves and flow meters: | | |
| £ 0.16 M(1996) x 1.054(2000) = £ 0.2 M(2000) | | |
| Total | £ 8.8 M(2000) | |

**TOTAL PRESENT CONSTRUCTION COST OF PROJECT (phase II)(2000)** | **109 M of US Dollar** |
3.7. Indicative Implementation Indices of the Project (Phase II)

The indices recommended hereinafter may be indicative for planning of water development projects which nature and scope are similar to the ones of Southern Conveyor Project, Phase II.

<table>
<thead>
<tr>
<th>ANALYSES</th>
<th>RECOMENDATION</th>
</tr>
</thead>
</table>
| **1. UNDERGROUND CONVEYORS OF WATER**
Cost of Dhiarizos Tunnel in thousands of US$ per 1 km of the Tunnel length apportioned to 1 m³/s of capacity of water conveyance.

\[ L_1 = \text{US$} \ 32.5 \text{ M} : 14.8 \text{ km} : 6.5 \text{ m}^3/\text{s} = \text{US$} \ 338 \text{ T} /\text{km}/(\text{m}^3/\text{s}) \]

It may be applicable for planning of investment in water conveyance projects with long and low-pressure tunnels as predominant work. The tunnels of internal diameter say up to 4 m driven by TBM in moderate to weak rock conditions. The water conveyance is achieved by gravity.

| **2. BURIED CONVEYORS OF WATER**
Cost of Tersephanou –Nicosia Conveyance System in thousands of US$ per 1 km of the System apportioned to 1 m³/s of capacity of water conveyance.

\[ L_2 = \text{US$} \ 14.1 \text{ M} : 37 \text{ km} : 0.9 \text{ m}^3/\text{s} = \text{US$} \ 423 \text{ T} /\text{km}/(\text{m}^3/\text{s}) \]

It may be applicable for planning of investment in water conveyance projects with long DI pipeline conveyors as predominant work. The conveyors may be combined of pumping and gravity mains with hydraulic heads ranging up to 25 bars.

| **3. IRRIGATION SYSTEMS**
Cost of Irrigation Distribution Systems of Akrotiri, Parkklishia and Kiti in thousands of US$ per 1 Ha of gross irrigation area.

\[ L_3 = \text{US$} \ 19.7 \text{ M} : 3 \ 909 \text{ Ha} = \text{US$} \ 5 \text{ T} /\text{Ha} \]

It may be applicable for planning of investment in moderate size of irrigation systems wherein the water conveyance is provided by gravity. Buried pipeline conveyors of DI, AC and PVC make up are applied. Storage reservoirs of 20 to 40 thousands cum of effective volume used as balancing tanks.

| **4. WATER TREATMENT PLANTS**
Cost of Limassol and Tersephanou Water Treatment Plants in thousands of US$ apportioned to 1 m³ of daily production of drinking water.

\[
\text{LWTP: US$} \ 19.7 \text{ M} : 80 \ 000 \text{ m}^3/\text{d} = \text{US$} \ 0.246 \text{ T} \\
\text{TWTP: US$} \ 21.1 \text{ M} : 90 \ 000 \text{ m}^3/\text{d} = \text{US$} \ 0.234 \text{ T} \\
\text{Average:} L_4 = \text{US$} \ 0.240 \text{ T} /(/m^3/d) \\
\]

It may be applicable for planning of investment in moderate size of plants with intensive physical and chemical treatment of water. Open water flow is achieved along the process of water treatment. DI pipes and fittings are used for indoor and outdoor water conveyance.

| **5. WATER PUMPING STATIONS (Supply and installation)**
Cost of Tersephanou Pumping Station in thousands of US$ apportioned to 1 MW of power consumption.

\[ L_5 = \text{US$} \ 1.9 \text{ M} : 3 \text{ MW} = \text{US$} \ 633 \text{ T} /\text{MW} \]

It may be applicable for planning of investment in pumping stations of about 1 m³/s capacity. Pumping head ranging up to 25 bars. Full antsurge protection of pumps is provided.
Conclusive Remarks:

1. The relationship $L_2 > L_1$, indicates that the ductile iron piping Manufacturers might have acquired monopolistic position in European market of piping industry.

2. The evaluated proportion 42%: 58% in total price of Tersephanou WTP of civil works versus E/M works, may indicate the following:
   a. Either the cost of civil works was underestimated by the C3 Contractor, or
   b. The manufacturers of process and E/M equipment for the plants seized monopolistic opportunities in European market of water treatment works, or
   c. Both options existed.

Whereas relatively standard and simple equipment embedded in the Plant, and extensive structural measures applied to take account of the differential movement of foundations, which could be caused by expansive montmorillonitic soils in foundation bedrock, a proportion of 50% : 50% of Civil and E/M cost components, was reasonable to expect.

3. Because of potential risks of the Contractor’s claims and of uncertainties accompanying completion of works, the Employer is advised to avoid multi-contract options for management and implementation of water conveyance, irrigation and water treatment projects.

3.8. Project Financing (Phase II)

Loans from: European Investment Bank

International Bank for Reconstruction and Development

Kuwait Fund for Arab Economic Development

Funding: REPUBLIC OF CYPRUS
3.9. Consulting Engineer’s Project Management Structure with key senior staff involved, (Phase II)

Note: *) Senior staff seconded by the Employer to the Consulting Engineer, in order to assist the Engineer in performing his duties included in Consultancy Services Agreement.
4. REFERENCED DOCUMENTATION


(2) SCP II - Geological Reports. Geological Survey Department, Nicosia, Cyprus, 1985 to 1989.

(3) Water Treatment and Desalination Plants in Cyprus. Report by Water Development Department, Cyprus, October 1999.

(4) Southern Conveyor Project, Cyprus. Report by Water Development Department, Cyprus, November 2000.


(8) Detailed electromechanical design for Tersephanou Water Treatment Plant in Cyprus, 1999. Sigma Engineering, Czech Republic.

5. CERTIFICATE ON COMPLETION

Republic of Cyprus

Ministry of Agriculture, Natural Resources & Environment

WATER DEVELOPMENT DEPARTMENT

File No.: 125/96
Tel. No.: 22803200
Fax No.: 22803381

27th August, 2003

Energoprojekt-Hidroinzenjering
12 Boulevard Mihailo Pupin
11 070 Novi Beograd
Serbia & Montenegro

Attention: Dr. T. Ninkov, Director

Dear Dr. Ninkov,

SCP2 – Consultancy Services
Operation of Components of the Project

Having been asked to express an opinion on the co-operation of our two organisations I am pleased to advise that this cooperation, which dates back since the mid-eighties and has ended with the trial runs and defects liability periods of the various components of the Southern Conveyor Project, Phase 2 has been a great success. Furthermore I am glad to inform you that the operation of the components continues to perform well to the satisfaction and benefit of the users.

I take this opportunity to thank all your Consultancy Staff involved in the various stages of the project for their valuable contribution to its successful completion.

Sincerely Yours,

CHRISTODoulos ARTEMIS
Director